NEW OBSERVATIONS ON THE TROPHIC ECOLOGY OF *LIZA GRANDISQUAMIS* (VALENCIENNES, 1836) (PISCES: MUGILIDAE) IN THE BONNY RIVER, NIGER DELTA, NIGERIA.

by

Richard P. KING (1)

ABSTRACT. - The trophic ecology of *Liza grandisquamis* in Bonny river, Niger Delta, Nigeria, was investigated over a period of ten months. Primary dietaries were fine particulate organic matter, mud and diatoms. Coarse particulate organic matter, sand, bluegreen, red and green algae, dinoflagellates, microarthropods, foraminiferans and nematodes were of secondary importance. Variations in food habit according to fish length, months and seasons are presented. Furthermore, the effects of two hydro-meteorological factors (rainfall, salinity) on food habits are given.

RESUME. - L'écologie alimentaire de *Liza grandisquamis* a été étudiée pendant dix mois dans la rivière Bonny, Delta du Niger, Nigéria. Les principaux constituants du régime alimentaire sont de fines particules de matière organique, de la vase et des diatomées. Les grosses particules de matière organique, le sable, les algues bleu-vertes, rouges et vertes, les dinoflagellés, les microarthopodes, les foraminifères et les nématodes sont d'importance secondaire. Les variations des habitudes alimentaires ont été étudiées en fonction de la longueur du poisson, du mois et de la saison. De plus, les effets de deux facteurs hydrométéorologiques (chute de pluie, salinité) sur les habitudes alimentaires sont donnés.

Key words: *Liza grandisquamis*, Mugilidae, Niger Delta, Nigeria, Ecology, Feeding behaviour.

Although a great deal has been documented on various aspects of the food and feeding habits of the Mugilidae (Odum, 1970; Pillay, 1972; Alvarez-Lajonchere, 1974, 1976; Buslé, 1981), there is still a dearth of information on the feeding ecology of the species in the Niger Delta, Nigeria. *Liza grandisquamis* is one of the most common and abundant mugilid in this area; it is exploited by artisanal fishermen and has great potentials for brackishwater culture in the mangrove swamps. However, apart from records of its occurrence (Boeseman, 1963; Pillay, 1965; Scott, 1966) and trial as a culture species (Pillay, 1965; Bardach *et al.*, 1972), little is known about its trophic ecology in the Niger Delta except brief reports by Pillay (1965) and Olaniyi (1984).

Various aspects of the feeding ecology of *L. grandisquamis* have however been investigated in Lagos lagoon, Nigeria (Fagade and Olaniyan, 1973) and in estuaries of Sierra Leone (Payne, 1976; Wilson, 1977). This paper completes a preliminary work on *L. grandisquamis* (King, 1986) and describes new aspects of trophic ecology in the Bonny river, Niger Delta, Nigeria, with particular reference to dietary shifts with fish size, monthly/seasonal dynamics in food preference and the effects of hydro-meteorological parameters on food preference.

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(1) Department of Zoology and Fisheries, University of Cross River State, P.M.B. 1017, Uyo, Cross River State, Nigeria.

Cybium 1988, 12 (1) : 23-36

The study area

This study was conducted in the Bonny river over a distance of 41 km, between Bonny town (4°30'N, 7°15'E) and Port-Harcourt (4°25'N, 7°03'E) (Fig. 1). This stretch lies within the brackishwater zone of the river. The Bonny basin has a tidal swamp of c. 60,762 ha. Mean tidal range at Bonny town is 1.35 m and 2.15 m at Port-Harcourt (Wokoma and Ezenwa, 1982). Mean monthly high and low tide salinities are 16.3 and 10.2% respectively whilst surface temperature is 29.2°C at Port-Harcourt; monthly fluctuations in these two parameters are summarized in figure 2. The vegetation of the mangrove swamp of the Bonny basin is dominated by *Rhizophora harrizonii, R. racemosa, R. mangle, Avicennia africana, Laguncularia racemosa, Nypa fruticans, Phoenix reclinata* and *Acrostichum aureum.*

Two major seasons are recognized in the area: the dry season (November-April) is characterized by the prevalence of dry north-easterly winds from the Sahara desert and the wet season (May-October) is characterized by the prevalence of moist south-westerly winds from the Atlantic Ocean.

The extent and prevailing meteorological conditions at Port-Harcourt are summarized in figure 2. More detailed description of the Bonny system is contained in Nedeco (1961), Scott (1966) and Dangana (1985).

MATERIALS AND METHODS

Samples of *L. grandisquamis* (Valenciennes, 1936) were collected during both day and night from the main channel and creeks of the Bonny river (Fig. 1) with cast nets (10-25 mm mesh size) over a 10-month period, between November, 1982 and October, 1983 (January and February 1983 excluded). They were mostly caught over muddy substratum and in mangrove environments, which are the preferred habitats of this species (King, 1986). The specimens were measured to the nearest mm total length (TL), preserved in 10% formalin and later dissected for the analysis of the stomach contents. The stomach contents of each specimen were placed in a Petri dish and the aggregates were dispersed with distilled water. Small alliquots were examined under a binocular microscope. The contents were identified and assessed by the Points Scheme and the Relative Frequency methods.

In the Points Scheme method (Hyslop, 1980), 20 points were alloted to each stomach regardless of fish size and they were shared amongst the various contents, taking account of their relative proportions by volume. Ten microscope fields of view were examined per stomach and mean points gained by each food category computed. The total of the mean points was calculated and expressed as percentage of grand total points gained by all stomach contents. The points scheme gave the percentage composition (PC) or bulk contribution of each item to total food composition.

In the Relative Frequency method, the frequencies of the variety of items in stomachs were noted and these data were used to evaluate their relative frequency by expressing the frequency of each as a percentage of the sum of the frequencies of all items according to the formula:

$$RF = 100\ (ai\ /\ \sum_{i=1}^{n} A)$$

where RF = relative frequency index, ai = frequency of item a and A = frequency of the n^{th} item. All RF values sum up to 100%. RF is unweighted by the actual amounts of items in the stomachs but is responsive to the frequency of each in relation to the frequencies of all others. RF is a modification of the occurrence method (Hyslop, 1980) commonly used in fish dietary analysis.

Food preference was assessed by an index of relative importance (IRI) devised by the author. It is computed as the summation of PC and RF of each item. Since PC

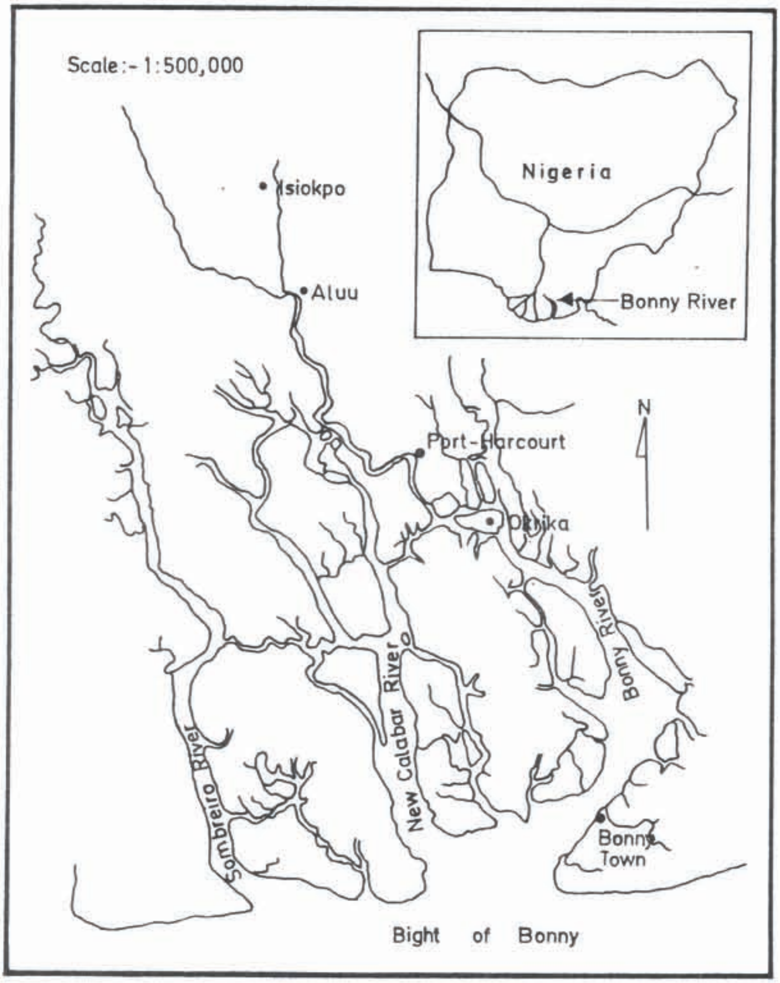

Fig. 1 : Map of eastern Niger Delta showing the Bonny river. Inset : Nigeria showing the position of the Bonny river.

and RF are percentages, each ranging from 0 to 100%, IRI ranges between 0 and 200%. The items with IRI ≥ 20% were arbitrarily considered as primary dietaries and those with IRI < 20% as secondary. The use of IRI to establish food preference is adequate as it incorporates the PC and RF data thus minimizing the bias characteristic of cases in which results from different analytical methods are independently interpreted.

PC and RF data were used to compute diet breadth based on Shannon-Weiner function, H, derived from the equation :

$$\overline{H}_{(PC)} \text{ or } \overline{H}_{(RF)} = -\sum_{1}^{s} (ni/N) \text{ Log } (ni/N)$$

where ni = percentage composition (PC) or relative ferquency (RF) of each item and N = total PC or RF of all dietaries.

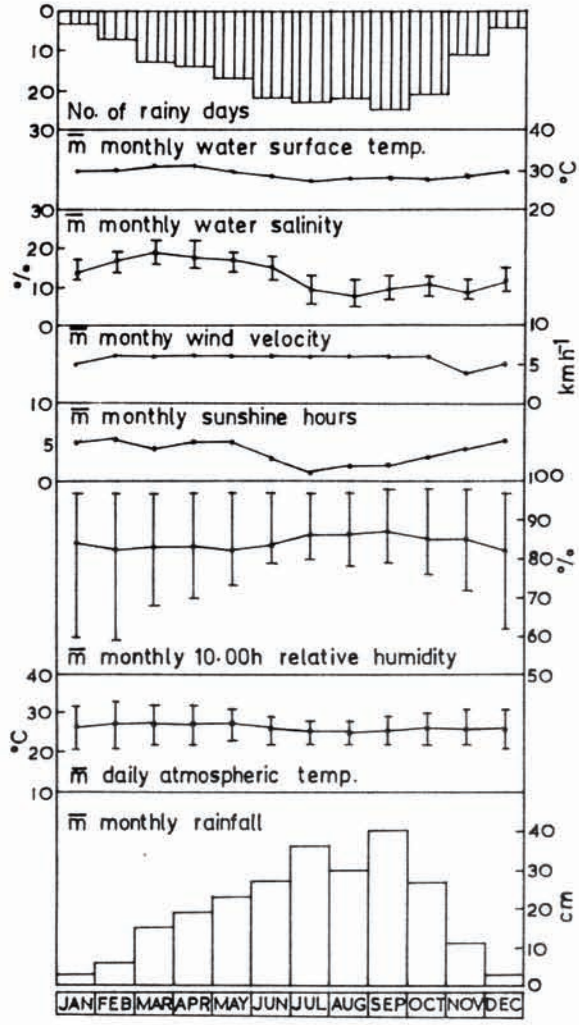

Fig. 2 : Summary of the climatic conditions, water temperature and salinity in the Bonny river basin at Port-Harcourt. Vertical lines are maximum and minimum values of the means.

The sizes of the inorganic particles (mostly silica granules) in the stomachs of 32 specimens (80 - 200 mm TL) were measured in mm using a binocular microscope fitted with an eyepiece graticule calibrated against a stage micrometer slide.

A total of 434 stomachs of *L. grandisquamis* (80 - 230 mm TL) were examined for food. The number of specimens examined per month and their size ranges are presented in Table I. A large number of specimens were examined in July since that sample contained a wide size range.

RESULTS

Most specimens caught during the night had fully distended stomachs whilst those caught during the day had empty or partially filled stomachs. This suggests that *L. grandisquamis* feeds more actively during the night than the day.

OVERALL FOOD COMPOSITION

The trophic spectrum of *L. grandisquamis* (Table II) shows that 12 major items constituted its diet. Fine particulate organic matter (FPOM), mud and diatoms are of primary importance, whilst coarse particulate organic matter (CPOM), sand, bluegreen, red and green algae, dinoflagellates, microarthropods, foraminiferans and free living nematodes are of secondary importance.

FPOM and CPOM are derived largely from decaying shed leaves of *Rhizophora*. Of the five algal categories (Table II), diatoms are the most important (IRI = 31%), and comprise particularly the benthic/pennate forms (*Bacillaria, Navicula, Gyrosigma, Pleurosigma, Nitzschia, Surirella*); planktonic/centric forms (*Coscinodiscus, Stephanodiscus, Cyclotella*) are rarely consumed. The bluegreen algae consist mainly of *Oscillatoria, Anabaena, Spirulina* and *Merismopedia* and the green algae, of *Closterium, Penium, Cosmarium* and euglenids. Epiphytic macro-red algae (*Bostrychia, Calaglossa*) were probably grazed from *Rhizophora* prop roots on which they are most commonly attached (Lawson, 1985). The dinoflagellates consumed are mostly *Ceratium* and *Peridinium* whilst the microarthropods comprise halacarid mites, ostracods and harpacticoid copepods.

The dominance of mud over sand in the diet (Table II) could be attributed to the species preference of muddy bottom deposits (Wilson, 1977; King, 1986).

L. grandisquamis ingests inorganic particles of mean size 0.024 ± 0.002 mm.

Table I : Number and size of *Liza grandisquamis* examined for food, November 1982 - October 1983 (January and February, 1983 exclusive).

Month	Number examined	TL range (mm)
November	58	130-220
December	26	200-220
March	36	140-220
April	40	80-170
May	30	110-160
June	32	170-230
July	116	80-220
August	30	80-100
September	34	140-170
October	32	130-160

Table II : Total trophic spectrum of *Liza grandisquamis* (80-230 mm TL; n = 434). RF : relative frequency; PC : percentage composition; IRI : index of relative importance.

Foods Items	RF	PC	IRI
Fine particulate organic matter	18,7	65,6	84,3
Coarse particulate organic matter	6,5	1,2	7,7
Mud	16,1	8,1	24,2
Sand	5,4	1,7	7,1
Diatoms	18,7	12,3	31,0
Bluegreen algae	12,3	4,4	16,7
Red algae	2,3	0,2	2,5
Green algae	11,9	5,0	16,9
Dinoflagellates	0,7	0,2	0,9
Microarthropods	1,9	0,3	2,2
Foraminiferans	1,7	0,3	2,0
Nematodes	3,8	0,7	4,5
Total	100	100	200

VARIATION WITH FISH SIZE

Figure 3 illustrates the variation in food richness (number of major items in the diet) in relation to fish length within the size ranges examined.

Food richness is positively correlated with fish size as shown by Spearman rank correlation coefficient (rs = 0.573, $P < 0.02$); this indicates that food richness increased with fish size.

The IRI of food categories in relation to fish size (Fig. 4) shows that a significant inverse relationship exists between fish size and the relative importance (RI) of FPOM (rs = - 0.521, $P < 0.02$), CPOM (rs = - 0.509, $P < 0.02$) and green algae (rs = - 0.531, $P < 0.02$); thus suggesting that the RI of these items decreases with increasing fish size. Conversely, a significant positive relationship occurs between fish size and the RI of red algae (rs = 0.764, $P < 0.002$), microarthropods (rs = 0.779, $P < 0.002$), foraminiferans (rs = 0.857, $P < 0.002$) and nematodes (rs = 0.525, $P < 0.02$) which portrays increases in the RI of these items with fish size.

No significant relationship exists between fish size and the RI of mud (rs = - 0.071, $P > 0.2$), sand (rs = 0.033, $P > 0.2$), diatoms (rs = - 0.320, $P > 0.2$) and bluegreen algae (rs = 0.231, $P > 0.2$); therefore the RI of each of these items varies randomly with fish size. Fish size is significantly positively correlated with diet breadth (Fig. 3) (rs = 0.529, $P < 0.02$ based on RF; rs = 0.683, $P < 0.002$ based in PC); this suggests a concurrent increase in diet breadth with growth.

TEMPORAL VARIATION

Two types of temporal dynamics in food habits were assessed: monthly and seasonal variations.

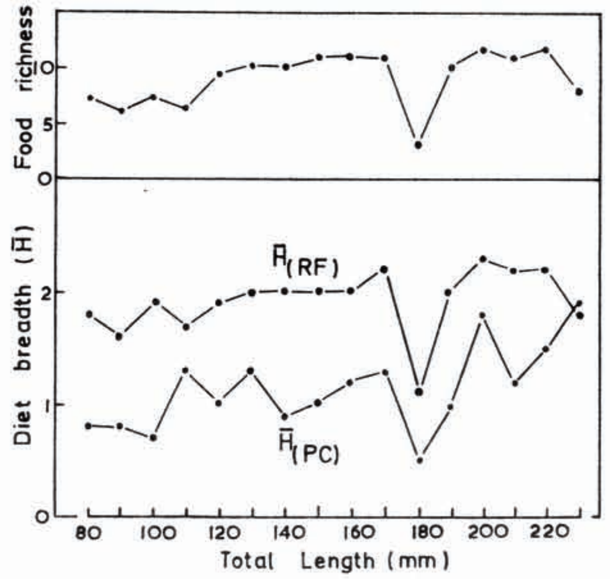

Fig. 3 : Variations in food richness and diet breadth of *L. grandisquamis* with fish length.

Monthly variation: Monthly dynamics in food richness (Fig. 5) shows that maximum richness occurs in December and March and minimum in August. Seven items (FPOM, CPOM, mud, sand, diatoms, bluegreen and green algae) consistently occur in the diet in all months while five others (red algae, dinoflagellates, nematodes, microarthropods, foraminiferans) occur only in certain months (Fig. 6).

Monthly rhythms in the RI of the food components (Fig. 6) depicted that FPOM is of primary importance in all months with a double maxima, in March and August; mud is primary dietary component from November to August, culminating in April; diatoms are primary dietaries in all months with peaks in November, April and July; green algae are of primary importance in April and September; CPOM, sand, red algae, dinoflagellates, microarthropods, nematodes and foraminiferans are secondary dietaries in all months.

Diet breadth data (Fig. 5) show that $\overline{H}$(RF) is consistently ≥ 2 in all months except April and August when values are < 2. Similarly, $\overline{H}$(PC) is > 1 in all months except March and July - September when values of < 1 are recorded.

Seasonal variation: Food richness is similar in both the dry and wet seasons (Table III). The composite data for the two seasons (Table III) show that the diet of *L. grandisquamis* is fairly similar in both seasons apart from the exclusion of dinoflagellates during the wet season and the higher relative importance of FPOM during the wet season and of mud and sand during the dry season. This similarity in food preference is corroborated by the high significant positive correlation between the RI of the dietaries in the two seasons ($rs = 0.939$, $P < 0.002$).

There is also no significant seasonality in diet breadth, $\overline{H}$(RF) (Table III) as shown by t - Test (Little and Hills, 1978) ($t = 0.840$, $P > 0.4$) but $\overline{H}$(PC) is significantly different during the two seasons ($t = 0.893$, $P < 0.4$); thus $\overline{H}$(PC) is significantly higher in the dry season than during the wet season (Table III).

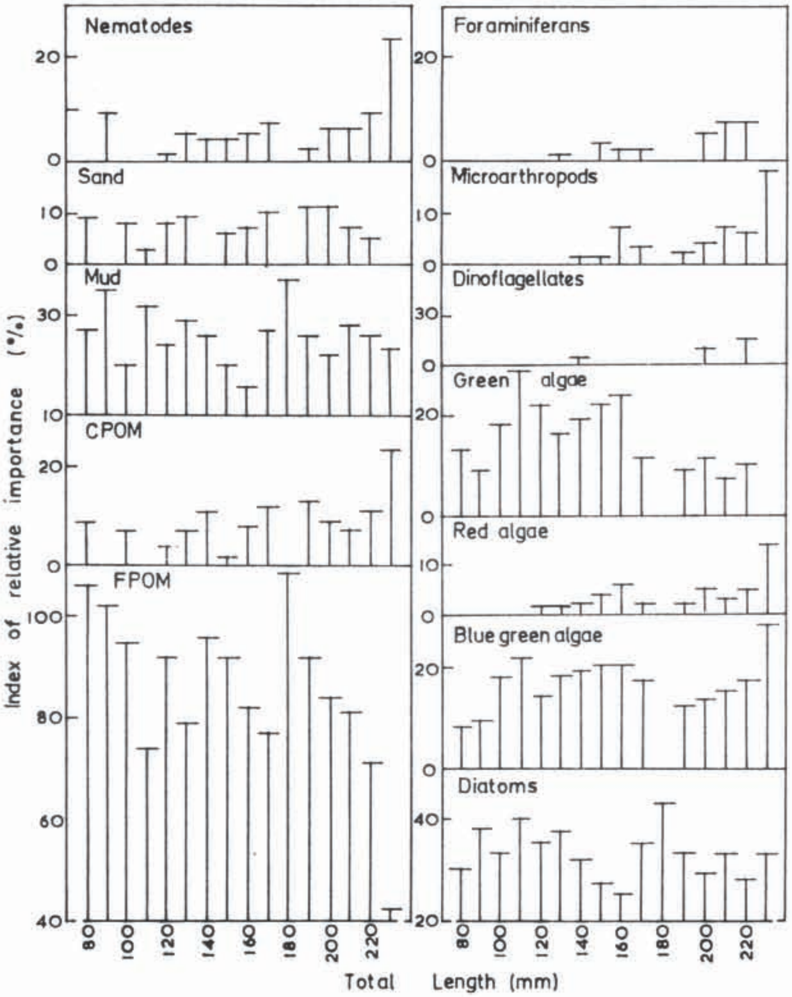

Fig. 4 : Variations in the index of relative importance of the dietaries of *L. grandisquamis* with fish length.

EFFECTS OF HYDRO-METEOROLOGICAL FACTORS

Temporal fluctuations in two hydro-meteorological parameters, rainfall and salinity (Fig. 2) were found to influence the food habits of *L. grandisquamis*. There is a significant positive relationship between rainfall intensity and the relative importance of FPOM (rs = 0.455, P = 0.2) and an inverse relationship between the former and the RI of sand (rs = - 0.891, $P < 0.002$); thus the relative importance of FPOM increases with rainfall intensity where as the reverse is the case for sand. The significant positive correlation between salinity and the RI of bluegreen algae (rs = 0.518, $P < 0.1$) suggests a simultaneous increase in the RI of the latter with salinity.

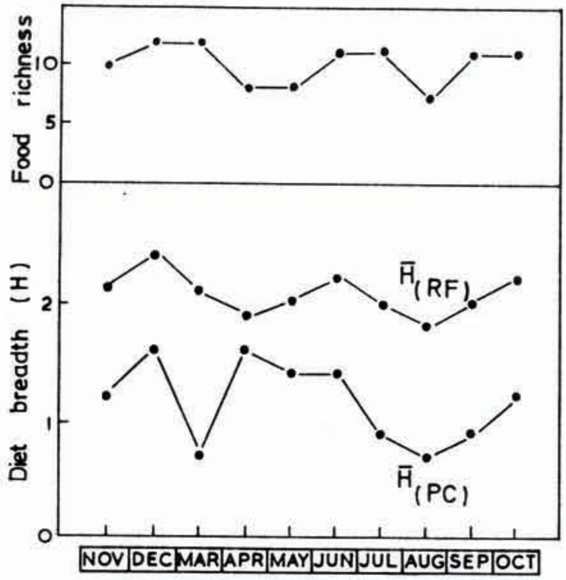

Fig. 5 : Monthly variations in food richness and diet breadth of *L. grandisquamis*

DISCUSSION

The results showed that the food composition of *L. grandisquamis* (Table II) comprised four main categories arranged in order of importance as follows:

(1) detritus (FPOM + CPOM; IRI = 92%)
(2) algae (mostly epipelic/episammic microalgae, epiphytic macroalgae; IRI = 68%)
(3) sediments (mud + sand; IRI = c. 31%)
(4) meiofauna (benthic microarthropods, foraminiferans, nematodes; IRI = c. 9%).

Further assessment of the food composition revealed that three items, FPOM, mud and diatoms were of primary importance whilst the rest (Table II) were of secondary importance.

The importance of detritus in the food of mugilids has been discussed by some workers (e.g. Pillay, 1972; Buslé, 1981) and it included the fact that it is rich in bacteria and protozoa which may be some nutritional value.

Similarly, mud is rich in amino acids, organic products of decay, bacteria and protozoa (Welcome, 1979).

The present study revealed that *L. grandisquamis* selectively ingested fine inorganic particles ranging between 0.022 and 0.026 mm. The inorganic particle size selection by other mugilids has been reported by Odum (1970), Pillay (1972), Capanna *et al.* (1974), Blaber (1976), Moriaty (1976) and Buslé (1981). The nutritional significance of fine particles is probably because they are richer in adsorbed/interstitial organic matter, bacteria, protozoa and other microorganisms than coarser particles (Odum, 1970; Pillay, 1972; Buslé, 1981). This is comparable to the nutritional advantage of the reliance of some freshwater fishes on fine inorganic particles (Bakare, 1970; Welcomme, 1979).

Pillay (1965) noted that *L. grandisquamis* fed predominantly on detritus and algae; Fagade and Olaniyan (1973) remarked that it fed on diatoms, sand and detritus;

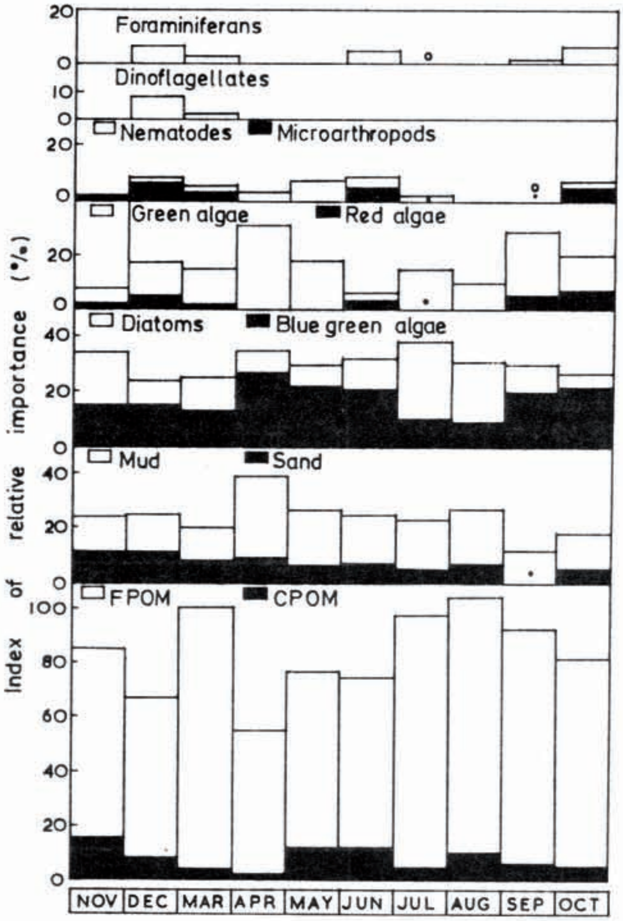

Fig. 6 : Monthly variations in the index of relative importance of the dietaries of *L. grandisquamis* o or . = IRI < 2%.

Olaniyi (1984) described the food as comprising mainly detritus whilst diatoms, algae, ostracods, copepods, nematodes and foraminiferans were of subsidiary importance. These reports are partly in concordance with the present results (Table II) except that a wider variety of items were consumed by the Bonny river population; for instance, the latter authors did not record the inclusion of red and green algae and halacarid mites in the diet of the populations they examined.

The change in diet with growth of *L. grandisquamis* (Figs 3 and 4), while agreeing with the observations of Pillay (1972) on *L. aurata* and *L. ramada*, Cain and Dean (1976) on *Mugil cephalus* and *M. curema*, Marias (1976) on *L. dumerili* and De Silva and Wijeyaratyne (1977) on *M. cephalus*, is at variance with that of Blaber (1977) who found no variation in diet according to the size of *L. macrolepis* and *M. cephalus*. Changes in food preference with growth not only minimises possible intraspecific competitive interactions between different cohorts but also offers a wider spectrum of food ressources for exploitation by the species; this may be important in maintaining large populations of different cohorts of the fish.

The dietaries of *L. grandisquamis* can be categorised into two groups on the basis of their monthly occurrence (Fig. 6) : constant elements, which occurred in all

Table III : dry and wet season trophic spectra of *Liza grandisquamis*. RF : relative frequency; PC : percentage composition; IRI : index of relative importance

Food items	Dry season			Wet season		
	RF	PC	IRI	RF	PC	IRI
Fine particulate organic matter	16,8	60,2	77	19,2	69,3	88,5
Coarse particulate organic matter	5,7	1,2	6,9	7,3	1,1	8,4
Mud	15,0	11,9	26,9	16,5	5,6	22,1
Sand	6,9	2,8	9,7	4,3	1,1	5,4
Diatoms	16,9	12,5	29,4	19,2	12,2	31,4
Bluegreen algae	13,3	3,8	17,1	12,4	4,7	17,1
Red algae	2,2	0,2	2,4	2,5	0,1	2,6
Green algae	12,2	5,5	17,7	11,6	4,6	16,2
Dinoflagellates	1,9	0,6	2,5	-	-	-
Microarthropods	2,3	0,4	2,7	1,7	0,3	2,0
Foraminiferans	2,2	0,3	2,5	1,7	0,3	2,0
Nematodes	4,6	0,6	5,2	3,6	0,7	4,3
Total	100	100	200	100	100	200
Means (± SD) diet breadth ($\bar{H}$)	2,1 ± 0,2	1,3 ± 0,4		2,0 ± 0,2	1,1 ± 0,3	
Mean food richness		10,5			9,8	
No. of specimens exam.		160			274	
TL range (mm)		80 - 220			80-230	

months (FPOM, CPOM, mud, sand, diatoms, bluegreen and green algae) and occasional elements, which occurred only in certain months (red algae, dinoflagellates, nematodes, microarthropods and foraminiferans). The type of trophic specialisation exhibited by *L. grandisquamis* based on its reliance on allochthonous FPOM and CPOM as primary and secondary dietaries respectively in all months and seasons (Fig. 6; Table III) is probably possible in the Bonny system since there is a vast mangrove swamp (Nedeco, 1961; Scott, 1966; Dangana, 1985) which ensures a constant input of these items through the shed leaves of *Rhizophora*.

Although there was considerable monthly dynamics in the RI of some dietaries (Fig. 6), pooled data for the dry and wet seasons (Table III) indicated that there was no substantial seasonality in food preference except for the higher relative importance of FPOM in the wet season and of mud and sand in the dry season. This is comparable to the absence of seasonal changes in the diets of *M. cephalus* and *L. macrolepis* (Pillay, 1972; Blaber, 1977). It is important to note that specimens of *L. grandisquamis* were not examined for food during January - February, a period which corresponds with an important part of the dry season.

A discernible seasonality could probably have emerged if fish were examined during the latter period.

The optimal foraging theory (Schoener, 1971; Pyke *et al.*, 1977; Angermeier, 1982) postulates an inverse relationship between diet breadth and resource abundances; thus diet breadth increases during periods of depressed resource abundances and *vice versa*. Evidence from a number of fish dietary reports in the tropics (Zazet and Rand, 1971; Welcomme, 1969, 1975, 1979; Lowe-Mc Connell 1975; Angermeier and Karr, 1983) suggests higher wet season abundances of food resources and lower levels of abundances during the dry season. Therefore, fish diet breadth should widen in the dry season but narrows in the wet season in conformity to the optimal foraging theory. The present study revealed that H(PC) was significantly higher ($P < 0.4$) during the dry season (Table III) in conformity to the optimal foraging theory.

The simultaneous increase in the relative importance of FPOM with rainfall intensity ($P = 0.2$) could be attributed to increased allochthonous input through run off from the fringing mangrove swamps. Payne (1976), Blaber (1977) and Wilson (1977) also reported increases in the RI of detritus in the diet of mugilids during the rains.

The significant inverse relationship between rainfall intensity and the RI of sand ($P = 0.2$) is perhaps due to the fact that the heavy rains deplete sediments of their nutrient content through 'washing', thus making them less nutritious to the fish. This may be corroborated by Bakare's (1970) finding, that bottom deposits in the Niger river become depleted of carbon and nitrogen during the flood season (= rainy season) and Payne's (1976) remark that the organic content of sediments in the Black Johnson estuary, Sierra Leone, is highest not during the peak of the rains but when the rains are abating and this was correlated with the period of peak abundance of the mugilids. The decline in nutrient content of the sediments during the rains probably accounts for the slight decrease in the RI of mud and sand in the diet of *L. grandisquamis* during the wet season, with a subsequent dry season increase when they must have been recharged with nutrients.

Perera and De Silva (1978) have demonstrated that digestion in young *M. cephalus* is salinity - dependent, the rate of digestion being faster with increasing salinity; this was correlated with higher food intake at lower salinities. In the present study, the RI of bluegreen algae in the diet of *L. grandisquamis* significantly increased with salinity ($P < 0.1$) but the precise nature of this relationship was not determined.

Acknowledgements. - My thanks go to Dr. S.A. Whyte, Fisheries/Hydrobiology unit, University of Port-Harcourt, Port-Harcourt, Nigeria, who gave valuable encouragements and guidance during this study. I am grateful to Mr. O.M. Udoidiong, Departments of Zoology and Fisheries, University of Cross River State, Uyo, Cross River State, Nigeria, and Dr. G.G. Teugels, Muséum National d'Histoire Naturelle, Ichtyologie Générale et Appliquée, Paris, France, for reading the manuscript and for valuable comments.

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Reçu le 24-10-86
Accepté pour publication le 03-03-87